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ondon School of Tropical Medicine.
(UNIVERSITY OF LONDON.)
Under the auspices of His Majesty's Government.
IN CONNECTION WITH THE
ROYAL VICTORIA AND ALBERT DOCKS
BRANCH HOSPITAL
OF THE
SEAMEN'S HOSPITAL SOCIETY.
(Incorporated by Act of Parliament, [illegible], Cap. [illegible].)

MALARIAL PROPHYLAXIS

IN SMALL COMMUNITIES IN BRITISH CENTRAL AFRICA

BEING A PAPER CONTRIBUTED BY
R. HOWARD, M.D., B.Ch.
(Trin. Coll., Oxon.)

FOR THE "CRAGGS RESEARCH PRIZE," 1906, AND HIGHLY COMMENDED.

SECOND EDITION.
ITH AN INTRODUCTION BY C. W. DANIELS, ESQ., M.B., M.R.C.P.
(Director of the London School of Tropical Medicine).

London:
JOHN BALE, SONS AND DANIELSSON, LTD.
OXFORD HOUSE
83-91, GREAT TITCHFIELD STREET, OXFORD STREET, W.

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IN

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BY

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PREFACE.

THE demand for a second edition of Dr. R. Howard's pamphlet on "Malarial Prophylaxis" within a few months of the publication of the first edition indicates the importance and usefulness of this account of the application of the general principles to small communities.

Successful results for large settlements have frequently been published, amongst the most striking of these being the extensive drainage experiments in Klang and Port Swettenham, which resulted in an annual diminution of the deaths from malaria from 307 to 46, of the cases of malaria admitted to hospital from 610 to 30, and of the deaths from all causes from 522 to 116.

These observations, published by Drs. Travers and Watson, formerly students of the London School of Tropical Medicine, are excellent illustrations of the results that can be obtained for towns by engineering works and by considerable expenditure, about £10,000 in four years—an expenditure, however, that is well repaid, even pecuniarily, by the results.

Such methods and expenditure are not practicable for small isolated communities such as the European mission, commercial and administrative settlements that are so common in the Tropics. Dr. R. Howard shows that in such circumstances much may be done if the local conditions are carefully investigated, and if the measures adopted are varied in accordance with these, with little expenditure of money. It is not to be wondered at that this paper has attracted serious attention, as in previous successful instances the cost has been so great that to many the schemes have appeared to be utopian.

Some expense must be incurred, but as this paper shows with an average strength of little more than thirty there is an average saving in invalidings and deaths of 2·3 per cent. of workers, the saving in passage money alone would amount to about £120 a year, so that expenditure of a considerably greater amount would still be economical.

Personally, as in 1899 and 1900 I visited most of the places mentioned, I have no hesitation in

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saying that the results are beyond my anticipations. A few important and not expensive reforms are still required and should be enforced. The most important of these is in the river steamers. In 1899 and previous years nearly a quarter of the people acquired their infection with malaria whilst travelling up the Zambesi and Shiré rivers. The necessity of abandoning the pernicious habit of tying up the steamer at night in the neighbourhood of a native village is obvious.

It is very satisfactory to note the general improvement in health in British Central Africa obtained by the adoption of partial and incomplete measures, and this should encourage the expectation that the adoption of more complete measures would render the country suitable for permanent habitation for Europeans.

C. W. D.

MALARIAL PROPHYLAXIS IN SMALL COMMUNITIES IN BRITISH CENTRAL AFRICA.[1]

By R. HOWARD, M.D., B.Ch., Trin. Coll., Oxon.

The general principles underlying modern malarial prophylaxis are now well known, and there are on record instances of their successful application in various parts of the world. This part of the dissertation is more directly concerned with that part of Central Africa known as Nyasaland, and it is proposed first to consider some general points in the geography and history of the country.

The British Central African Protectorate, or, as it is sometimes more appropriately called, Nyasaland, consists of a strip of territory 550 miles long and 100 miles wide, its northern portion bordering the western shore of Lake Nyasa, and stretching thence southwards for about 200 miles on both banks of the River Shiré, which flows out of the lake. British territory ends on the left bank of the river at Chiromo, where the Ruo joins the Shiré, and on the right bank at Port Herald, 50 miles further south. From hence to the sea the river passes through Portuguese territory, but the waterway was by treaty declared international. This country lies well within the Tropics, the northern limit being 10° south latitude and the southern 17° south latitude. Lake Nyasa itself is about 1,500 ft. above the level of the sea; the surrounding hills rise rapidly, so that most of the country to the west is 3,000 ft. or more above sea-level. The River Shiré on leaving the lake flows through level country for 80 miles, and then falls rapidly in a series of cataracts, the Murchison Falls, and is for 50 miles quite unnavigable until Katungas is reached. From this point onwards it flows through level alluvial soil, and about 100 miles from the sea it joins the Zambesi.

The hilly country to the east of the cataracts is called the Shiré Highlands; it is a plateau of 3,000 to 4,000 ft. above sea-level, and it is here that the seat of government and most of the European settlements and industries have been established in late years.

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[1] Being a paper contributed for the "Craggs Research Prize," 1906, and highly commended.

The first exploration of this territory was almost entirely due to the travels of David Livingstone; it was he who first discovered Lake Nyasa in 1859.

The first attempt to form a white settlement was made in 1861, when a pioneer party of the Universities' Mission to Central Africa established themselves in the Shiré Highlands. War, famine, illness, and death forced them to withdraw in 1863. In 1875, after Livingstone's death, two Scotch missions were established, one on the western shore of Lake Nyasa, the other in the Shiré Highlands at a place which was named Blantyre, after Livingstone's birthplace. This has since grown to be the main trading centre of the Protectorate.

In 1884 the Universities' Mission, which had in the meantime been working in Zanzibar, opened a station at Likoma, an island in Lake Nyasa, and built a steamer to work along the eastern shore of the lake.

From this time onwards an increasing number of planters and traders were attracted to the country, and in 1891 a British Protectorate was declared. Prior to this date the only information as to the health of the European settlers is that contained in the statistics and publications of the various missions, but from this time onwards there is the information supplied in the annual Government Blue Book.[1]

The settlement of the Scotch Mission on Lake Nyasa proved very unhealthy, and a few years later it was moved to a better site at Bandawe, half-way up the western shore. The higher plateau of the Shiré Highlands proved healthier. Some of the earlier settlers and explorers had gained previous experience of tropical life elsewhere; many of them were picked men, and all had gained a practical, though not theoretical, knowledge of how to avoid fever. Moreover, the European stations were scattered; they were generally on carefully chosen sites, and they were away from native villages because the suspicious natives would naturally not welcome the foreigner into their midst. These advantages more than counterbalanced the drawbacks that are a constant accompaniment of pioneer settlements in Africa, such as inadequate housing, shortness of provisions, and lack of hospital and nursing accommodation.

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[1] "Reports on the Trade and General Conditions of the British Central Africa Protectorate." See also "British Central Africa." H. H. Johnston (Methuen). "Health in Africa." Kerr Cross (Nisbet and Co.).

With the declaration of the Protectorate came a great influx of Europeans. They were for the most part unseasoned men, and had little idea of the discipline and limitations necessary for health in the Tropics. The country was more settled and the natives were more friendly, with the result that the trader not infrequently built his house and store in the midst of a native village, and it was the custom for huts for the accommodation of native servants and workmen to be built quite close to European dwellings.

The new settlers not only occupied the healthier Shiré Highlands, but a considerable number were employed on the Upper and Lower Shiré and on Lake Nyasa. It is true that as the country became opened up and transport became easier houses improved, and the general standard of comfort rose, but accompanying this in some places was the introduction of irrigation in order to improve the gardens. At this time malaria was regarded as the natural accompaniment of life in Africa, and too often it was thought little of and neglected.

The result of all these factors was to produce a period of remarkably bad health. Severe or fatal attacks of malaria occurred, and there was a most alarming increase of malarial hæmoglobinuria, or blackwater fever, which was at that time a little-known disease. During the official year, from April 1, 1895, to March 31, 1896, the European death-rate was ninety-seven per thousand. Of the total twenty-eight deaths, twenty were due to malarial fevers, and of these sixteen to blackwater fever; and the consensus of opinion was that the recent increase of this complaint was quite out of proportion to the increase in the white population. The next year was little better; the death-rate was eighty per thousand; blackwater fever was very prevalent, and it appeared at stations which had hitherto escaped and were considered comparatively healthy.

The following year, 1897-8, the condition of affairs was even worse; the mortality rose to 120 per thousand, and this occurred in a population where the great majority were young men in the prime of life.

In 1898-9 the death-rate was much less, viz., forty-five per thousand, but of the total of sixteen deaths, eleven were due to blackwater fever, as against nine of the year before, so that this disease showed no decline. The improvement was attributed by the principal medical officer partly to better housing, partly to the increase of the medical and nursing staff, and partly also to the medical examination of officials prior to their acceptance for work in Africa.

This alarming mortality caused great concern in England, and the Foreign Office was petitioned to send out a Medical Commission to investigate malaria and blackwater fever. In this same year came Ross's discovery, and the enunciation of the mosquito malaria theory. With the assistance of the Foreign Office, the Royal Society decided to send out a Commission with instructions to proceed first to British Central Africa.

Report of the Malaria Commission.

The three Commissioners, Drs. Daniels, Stephens, and Christophers, arrived in Blantyre in April, 1899. They devoted special attention to the study of blackwater fever in its relation to malaria, and they all agreed that there was undoubtedly a close relationship between the two diseases, and that the more severe the endemic malaria, the greater the number of cases of blackwater fever in that locality.

They regarded blackwater fever as a special complication, which was liable to occur under certain conditions of malarial infection, and not as a specific disease.

Drs. Stephens and Christophers directed their further attention mainly to the study of the malaria parasite. They found only one variety present both in natives and Europeans, and this they declared to be morphologically identical with the æstivo-autumnal or malignant tertian parasite of the Italians. They noted, however, that frequently very few parasites appeared in the peripheral blood, and that sexual forms (crescents or gametocytes) were but rarely found in the blood of Europeans.

During the same year, similar observations were made by Koch on the East Coast of Africa and in New Guinea, and by Ziemann in the Cameroons, the only difference being that on the East Coast, Koch found that 10 per cent. of the cases had the benign tertian parasite.

The presence of only one type of parasite simplifies observations on the effect of prophylactic measures. In a country like India, where two or three types are often found in the same locality, considerable difficulty may arise, for it is clear that the mere demonstration that a certain percentage of native children in a given district harbour a malarial parasite, or that a certain percentage of anophelina contain sporozoits, really gives very little definite information of the risk to life and health run by European settlers, since this will depend very largely on the types to which these parasites belong.

Dr. Daniels investigated the distribution of mosquitoes. The Liverpool School of Tropical Medicine expeditions which had been despatched to the West Coast towns, had incriminated *Anopheles* (*Pyretophorus costalis*) as the main carrier of malaria in that region. Daniels showed that in British Central Africa, an anopheline (*Myzomyia funesta*) was much the most widely distributed variety, and he demonstrated that it was capable of carrying malaria.

M. funesta is a country mosquito, breeding in springs, streams, and rivers, whereas *P. costalis* lives in towns, and breeds mainly in puddles.

In the Shiré Highlands, *e.g.*, at Blantyre, it is frequently stated by the residents that there are no mosquitoes, but Daniels demonstrated larvæ in almost every valley during the wet season, and in eleven or twelve places during the dry season, within the limits of the township. Mere elevation of the country did not seem to have much effect, for larvæ were found from 5,000 ft. above sea-level downwards. In some places, *e.g.*, Zomba, the Government headquarters, irrigation was shown to have greatly increased the anopheles' breeding grounds.

In the River Shiré the larvæ were found where thick grass and reeds grew out into the water, thus preventing the access of fish. In the upper part of the river, between Lake Nyasa and the Cataracts, a kind of grass with floating roots was very abundant. Here larvæ bred freely, and as the river contained plenty of water all the year round, the dry season in no way checked their numbers.

These facts readily accounted for the bad health record of Fort Johnson and other places on the banks.

The presence of *M. funesta* was confirmed at various places on the shores of Lake Nyasa, but no very detailed observations were published.

As regards prophylaxis, Daniels considered that no radical system of mosquito destruction was feasible, but that protection against mosquitoes, preferably by means of a mosquito-proof room built inside the house, and segregation of Europeans, must be relied on.

In the neighbourhood of the River Shiré, clearing the banks of grass and reeds in the vicinity of the townships would reduce the number of anophelines; and as many travellers to the Highlands became infected during their journey on the river, the steamers might be made mosquito-proof, and the time occupied by the journey curtailed.

Finally, he considered that the hope often expressed that the country would become more healthy as it became more settled, and advanced in civilisation, was not likely to be realised unless definite prophylactic measures were taken. In recent years some of these proposals have been carried into effect.

Thus, at Fort Johnston the river banks have been cleared and built up, a measure resulting in a marked diminution of anophelines. Also in most townships native huts have been removed and built outside the boundaries, and thus some degree of European segregation has been obtained. Moreover, sanitation and the clearing away of grass and scrub within the townships have been attended to. No improvement of the river steamers has been attempted, however.

The result of these measures, as judged by the Blue Book returns, has been a decided improvement in the health of the European community. There has been a gradual diminution in the death-rate. The year 1901-2 was reported by the principal medical officer as the healthiest since the occupation of the country, only twelve deaths from all causes having been registered. The following year, in spite of an increase in the population, there were only thirteen deaths, giving a mortality of twenty-eight per thousand. The next year it was thirty-five per thousand, and for 1904-5 it was twenty-seven per thousand. One point requiring further elucidation is the relative healthiness of the Shiré Highlands compared with the level of Lake Nyasa. Dr. Daniels showed that the Highlands were well watered, and that *M. funesta* bred in many places.

The explanation is probably to be found in the cooler temperature, which hinders the development of mosquitoes. The rainy season lasts from November till April. As soon as the rains are over, while the level of the sub-soil water is still high, and the conditions generally favourable to the formation of anopheles' breeding grounds, the weather turns cold, and during May, June, and July the thermometer not infrequently falls as low as 40° to 45° F.

On the lake level, however, there is no such check. Observations taken by the writer at Likoma on Lake Nyasa show that the minimum temperature is very seldom below 60° F., and that anophelines are specially prevalent during these months.

Whatever may be the explanation, the fact remains that mosquitoes are not very noticeable at Blantyre. There are few culicines, and *M. funesta*, which makes relatively little noise, and generally attacks at night, passes unremarked. In spite of the observations of the Malarial Commission, residents at Blantyre still frequently declare that there are no mosquitoes, and discard the use of a net.

It is not surprising that the Blue Book of 1903-4 notices a good deal of ill-health at Blantyre. The reason that malaria is not more prevalent than it is may be found in the segregation of Europeans that has been effected.

A study of the Blue Book statistics shows very clearly that malaria is the only disease with which European settlers in British Central Africa have to seriously contend. Typhoid, cholera, plague,[1] and yellow fever are absent. Dysentery is fairly common in some places during the dry season, when good water is scarce. As regards the neighbourhood of Lake Nyasa, however, this does not apply ; the natives living on its shores can always obtain excellent water from the lake, which is perfectly fresh and very deep, so that among them dysentery is quite uncommon, and is generally due to a journey inland.

Malarial Prophylaxis at Isolated Stations.

The foregoing historical survey shows that attention has been directed mainly towards the study of malarial prophylaxis in towns. In this dissertation it is proposed to consider how the principles above discussed may be applied on a small scale in the case of settlers living in country districts. Certain typical stations will be described in detail, special attention being paid to the distribution and habitat of mosquitoes in their vicinity. The methods of prophylaxis which have been adopted will be given, and their efficacy tested by a reference to the health record of the station in question. This will be followed by a general summary of the conclusions arrived at, and by a statement of the precautions which should be adopted when founding new settlements in the future.

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[1] Plague was introduced into the Port of Chinde, at the mouth of the Zambesi, from India, in October, 1905, but was speedily suppressed.

The particular stations described are some of those occupied by the members of the Universities' Mission to Central Africa, in the vicinity of Lake Nyasa. They are, however, essentially similar to many other country settlements situated in other parts of Nyasaland, and the experience gained may be equally well applied elsewhere ; indeed, in the healthier highlands the difficulties of efficient prophylaxis would be less, and the results should be even more encouraging.

General Precautions.

In order to avoid repetition it will be advisable first to enumerate certain precautionary measures which are of general application :—

(1) Every resident in Tropical Africa should use a mosquito net constantly. A suitable net is undoubtedly a great protection, but it is extraordinary what lack of intelligence in its use is often witnessed. The practice of only putting the net down if mosquitoes are noticed should be absolutely condemned ; no station has been found to be free from mosquitoes, hence the net should invariably be used whether the insects are seen or not.

The bites of anophelines, if they occur during sleep, often pass unobserved ; it is quite common to find full-fed specimens in a house in the morning, although the occupant is quite unconscious of having been bitten.

The mosquito is enabled to feed undisturbed on a sleeping person, and so sucks out again most of the irritant which it injected. If the insect is disturbed as soon as it has punctured, as frequently happens during the evening, the irritation is far greater. It is these evening mosquitoes that attract most attention; these are often *Mansonia uniformis* or other culicines.

The net should be of ample size, at least 7 ft. long and 3 ft. wide, and not less than 5 ft. high. It is best hung from a rectangular frame suspended from the ceiling over the bed. There should be 2 ft. of calico sewn round the bottom outside the net. This saves the netting and keeps it from tearing where it is tucked in under the mattress, and also protects the sleeper from getting bitten through the net. The size of the bedstead is also very important. It should measure not less than 7 ft. 6 in. by 3 ft. 6 in. With a large bedstead the net is well stretched out and therefore cooler, while the sleeper is much less likely to rest any portion of his body against the sides of the net.

Camp beds, 2 ft. by 6 ft. 6 in., may be a necessity while travelling, but should never be in use at a fixed station.

Fine mosquito netting (eighteen holes to the inch) is efficient in keeping out all mosquitoes in British Central Africa.

A muslin net may be an advantage where there are sand-flies, but it is much hotter.

Once the mosquito-net habit is formed there is no temptation to give it up; it is a wonderful protection, not only against mosquitoes, but also against many things that are liable to disturb the night's rest in the Tropics, such as bats, snakes, flies, rats, &c.

A net should last a year, even with the rough usage necessitated by travelling; if stationary it will last double the time. An accidental tear can be patched up, but when the threads become rotten and minute holes begin to appear all over, it is useless to attempt to mend it, and it should be destroyed. A net with holes is worse than none; it gives a false sense of security, but no protection, and is really a mosquito trap. Daniels suggested that small mosquito houses of wire gauze with the bed inside would be preferable, but they have not found favour in British Central Africa. An ordinary net, if properly used, is quite efficient, and it is easier to keep clean and to move about.

(2) It is important to avoid waiting about after sunset on the lake shore or in native villages as far as possible. As will be shown in the following pages, the

neighbourhood of the lake shore is the great anopheles' breeding ground, the second part of the rule follows from the observations of Stephens and Christophers mentioned above.

Of course, if a steamer comes in at night it may be necessary to go down to the lake shore, or the clergy or doctors, or nurses may be summoned to visit natives in their villages. These are risks incidental in the work of a missionary which cannot be avoided, and the danger of being bitten by mosquitoes when walking is much less than when waiting about. It may be very pleasant to stroll on the shore on a moonlight night, but it is unnecessary and dangerous, and should be avoided.

(3) *Destruction of Culicine Larvæ.*—On every station before the wet season begins, all old tins, pots, &c., should be collected and buried in a pit. During the rainy season the long grass throughout the compound, but especially round kitchens, sculleries, &c., should be kept down, so as to remove cover where rubbish can lie hid, and all fresh tins opened in the kitchen should be thrown into a pit provided for the purpose and covered with earth. On Lake Nyasa there are about seven months of the year without rain, and then no precautions are needed. It is very important to make the collection before the rains, for when the grass has once begun to grow it may be very hard to find the rubbish and numbers of breeding places may escape notice. It is remarkable what a reduction in the number of culicines may be obtained by the enforcement of this rule, even when applied to one single isolated European station.

LIKOMA.

Physical Characteristics.

Likoma is an island, 4½ miles long by 2½ miles wide, lying near the eastern shore of Lake Nyasa. It rises out of deep water, and is a mass of granite rock with overlying sandy soil, through which granite boulders protrude. There is a central hilly backbone which rises to about 540 ft. above the level of the lake. At some parts the hills descend abruptly to the water, elsewhere there are sandy plains between them and the lake. The shore is sandy or rocky, and is not fringed with reeds or water-plants.

The climate is pleasant for nine months in the year. From October to December, however, it is hot and oppressive, especially at nights. At this time of year there is little vegetation, and the ground is scorched. The rocky boulders absorb heat in the daytime and give it out at night, making the air hot. The highest shade temperature that has been observed was 98° F., and the lowest 58° F. Sudden changes of temperature do not occur.

The rainy season is from December, or sometimes November, till April ; from May to October rain hardly ever falls. Observations made during the last eight years give an average rainfall of 39 in. per annum, which approximates nearly to that which has been determined for the valley of the River Shiré.

Owing to the sandy nature of the soil the rain rapidly soaks in, and the surface of the ground is quite dry within an hour after a tropical deluge. There is practically no sub-soil water until the level of the lake is reached. No pit dug inland remains full of water, even during the wet season.

There are no permanent springs or rivers, but during the rains there are a few short streams.

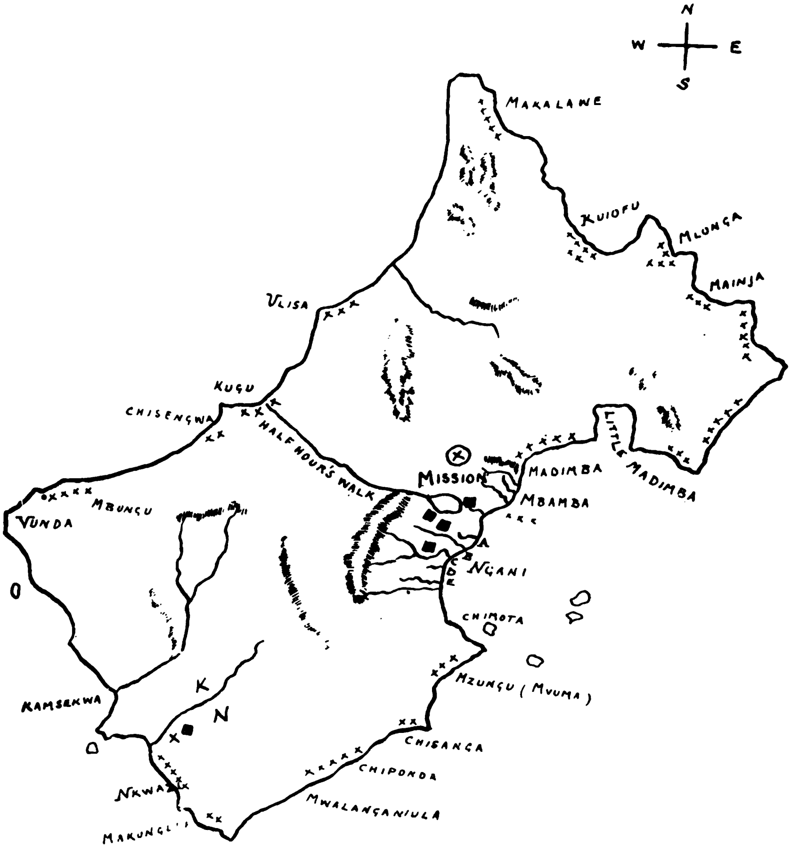
The native population is about 3,000. The native villages are all built close to the shore in the little bays in which the island abounds. In the days of the slave raids Likoma was a secure place of refuge ; this accounts for the large native population on such a barren spot.

Early History of the European Settlement, 1885-98.—Considerations of safety, coupled with the excellence of the harbour, determined the selection of Likoma as the head station of the Universities' Mission in 1885. Since that date it has been occupied continuously, the number of Europeans varying between six and twelve.

The actual site chosen was on sloping ground, 600 yards away from the lake, and about 100 ft. above it, almost equi-distant from the two native villages Mbamba and Ngani, which are on the lake shore. (*See* map, p. 16.)

The first houses were only wattle and daub erections, and the style of living was very rough ; food was poor, and difficult to obtain. There was also a general disregard of hygienic principles and of the precautions necessary for life in a tropical climate.

The conditions gradually improved, and the standard



MAP OF LIKOMA, SHOWING THE STREAMS OF NGANI, MBAMBA, AND NKWAZI.

of comfort was raised. From 1894 onwards, intending candidates were subjected to a rigorous medical examination before going to Africa. Good stone-and-brick houses were built, fruit and vegetables were obtained from a garden on the mainland, and the commissariat greatly improved.

During the first eight years of this period, 1885-92, there were six workers who had previously spent a considerable time in Zanzibar or on the East Coast, and were more or less acclimatised. These all had very fair health. Nine others, who were new to the country, had very poor health; three of them died, and five were invalided. The three following years, 1893-95, were even worse. Of ten new members, three died and six were invalided. The next three years, 1896-98, showed some improvement; but even so, out of thirteen new members two died and four were invalided.

Subjoined is a summary of these statistics in tabular form; only those workers who have spent more than six consecutive months at the station are included:—

SUMMARY OF EUROPEAN HEALTH RECORD, 1885-98.

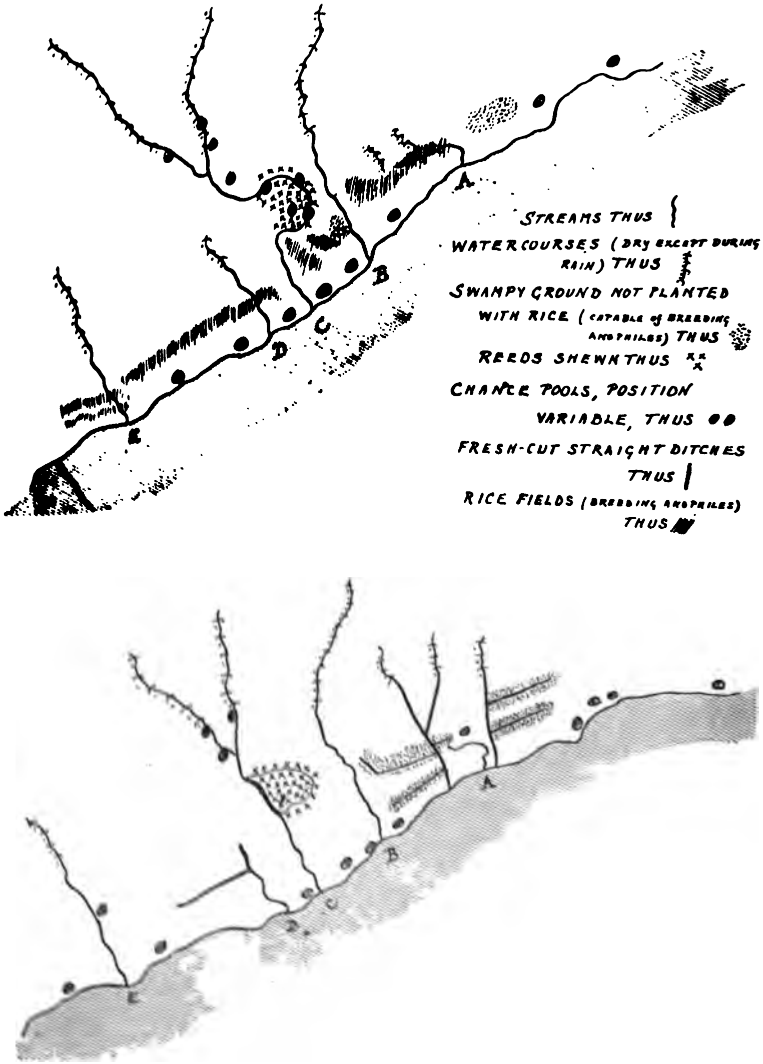
Total number of workers ..	38	(Six of these were acclimatised, the rest were new to the country.)
Total number invalided ..	15	
Total number of deaths ..	8	
Total number of patients ..	8	

The average length of residence at Likoma of each worker was two years; this gives an annual invaliding rate of 197 per thousand, and a death-rate of 105 per thousand.

STATISTICS OF BLACKWATER FEVER.

Total number of patients ..	8	
Total number of attacks ..	12	(Two patients had two attacks, and one three.)
Total number of deaths ..	4,	*i.e.*, a case mortality of 33½ per cent.

With the end of 1898 the first period of the history of the settlement closes; from 1899 onwards there has always been either a doctor or a nurse on the island; systematic observations of the mosquitoes have been taken, and the attempt made to introduce a rational system of malarial prophylaxis. A comparison between


A
B
C
D
E
STREAMS THUS
WATERCOURSES (DRY EXCEPT DURING RAIN) THUS
SWAMPY GROUND NOT PLANTED WITH RICE (CAPABLE OF BREEDING ANOPHILES) THUS
REEDS SHEWN THUS
CHANCE POOLS, POSITION VARIABLE, THUS ●●
FRESH-CUT STRAIGHT DITCHES THUS
RICE FIELDS (BREEDING ANOPHILES) THUS
A
B
C
D
E

PLANS OF NGANI RICE SWAMP AND ATTEMPTED IMPROVEMENT, 1904.

the health records of the two periods will show the value of the methods employed.

Observations on Mosquitoes and Methods of Malarial Prophylaxis, 1899-1905.

It was found that mosquitoes were never very prevalent on the European station. During the wet season, from December to April, *Stegomyia* and other culicines occurred in considerable numbers, and were sufficient to cause annoyance. From May to November they were practically absent. An investigation showed that they were bred almost entirely locally, in old tins, &c., and since a mosquito brigade has been organised just before the rainy season each year, there has been a marked reduction in their numbers.

Anophelines are never plentiful, but they visit the station in small numbers. It is noticeable that while culicines appear as soon as the rainy season begins, anophelines are seldom found before February, but they continue to be observed up till May or June. They are seldom found early in the evening; they enter the houses at night, after the lights are out, and are found there in the early morning. From July onwards they are very rarely to be found.

From observations made in 1900 it was proved that in the case of culicines caught on the station, the number of males and females was nearly equal, whereas, of the anophelines only 5 per cent. were males. This, doubtless, is explained by the facts mentioned below as to the distance of the anopheline breeding places. They are but occasional visitors, and it is only the longer-lived females that succeed in reaching the station.

The dry, sandy character of the island has already been mentioned, the result of this being that there are no natural waters until the vicinity of the lake is reached, and the station itself is quite free from anopheline breeding grounds. It may be mentioned that in 1904-5 extensive building operations were being carried out, and water for puddling clay was daily brought from the lake and poured into the clay pit. Although this pool was constantly stirred up during the day, anopheline larvæ were observed on several occasions as soon as it had settled in the evening, and paraffin had to be applied to it. In fact, this acted as a test pool, and showed how readily anophelines would avail themselves of any suitable water.

On the other hand, anopheline larvæ have *never* been found in tins or other culicine breeding places on the station.

In the neighbourhood of the lake there are streams which rise as springs in the sand, with a dry watercourse above. They are quite short for the most part, about 100 yards long, and they do not begin to flow until the rainy season has been established a month or so. If the rains come early they may be found running in December, in other years not till February. The actual course of the streams is variable; a sudden rush of rain-water will cut quite a new channel through the beach to the lake.

A heavy storm brings down quantities of sand, which, meeting the waves of the lake, is thrown up as a bar at the mouth of each stream, behind which the water collects as a pond. With every heavy rain the water cuts through this bar and reaches the lake, but during a few consecutive fine days the ordinary flow of the stream escapes by soaking through the sand.

The level of the lake rises about 3 ft. during the rainy season, and falls again gradually during the succeeding dry season. In April or May the streams cease running, but the ponds at their mouths remain. The water in these is kept fresh by soakage from the lake through the sand of the bar. It is only as the lake-level falls that these ponds dry up; this generally occurs about August.

Early in the rainy season fish make their way up the streams to spawn, so that the ponds and streams are soon full of young fry. These effectually destroy anopheline larvæ, and at the beginning of the wet season the latter are only found where they are out of reach of the fish. Such places, however, are only too plentiful. Reeds or grass may grow in the course of the stream and so give shelter, or some slight obstruction may cause an eddy which, during a rainstorm, scoops out a pool in the sand. As the water subsides, the pool is left securely shut off from the main stream which contains fish, and is kept fresh by the soakage through the sand of the water running close to it. Such pools form ideal breeding places, and are often crowded with larvæ.

In addition to the streams, there are a few subsidiary breeding places; firstly, pools among the rocks on the shore, formed by the waves during a storm; secondly, holes dug in the sandy shore by the natives. They bury their cassava in the wet sand just above the lake-level, and often when they dig it up a pool is left. Larvæ may be found at times in these situations, but they are unsafe breeding places, for, if a storm arises, the waves will wash the larvæ out into the lake. Thirdly, larvæ have also been found in the rain-water contained in an abandoned canoe, with algæ growing on its sides. They have never been found in the open water of the lake, the presence of fish rendering it quite unsuitable.

It will be seen that in the neighbourhood of the lake shore breeding places are very plentiful during the wet season, and larvæ are to be found in abundance as soon as ever the conditions become favourable. So long as the rains continue, however, there is always the possibility of the streams being flushed out, and the larvæ carried to the lake, where they would speedily perish. This contingency helps to keep down the number of anopheles.

After the rains are over, and the streams cease running, the fish disappear from the ponds, either reaching the lake or dying, and then larvæ can develop without danger.

In May and June anophelines are particularly plentiful, and, as previously stated, it is at this season that they reach the European station in the greatest numbers. These are the coldest months of the year.

In the Highlands the temperature falls sufficiently to exercise a definite check on the increase of anophelines, but at Likoma, owing to its higher mean temperature, no such effect is observed.

As the lake falls the ponds get smaller, and by August they are dry. Larvæ remain present till the end, even when the water is quite stagnant. Apparently enough fresh water soaks through the bar from the lake to supply their needs. On one occasion they were found when all that remained was a small muddy puddle regularly stirred up by ducks.

From August onwards, there are no anopheline breeding grounds, except the occasional holes dug in the lake shore by the natives. The anophelines gradually decrease in numbers, but some must live on in the adjacent native huts for five months, for as soon as ever the streams begin to flow larvæ reappear in numbers. Thus the "æstivation" of anopheles at Likoma, in the absence of breeding places, lasts five months, and is even more marked than that recorded by Stephens and Christophers at Sierra Leone. During this period, however, few anophelines reach the European station; they keep close to the native villages on the lake shore.

The distribution of anopheline breeding places is similar all round the island, but it is only the streams at Mbamba and Ngani that need to be considered here, the others being too far away from the station to have any effect.

The following description is taken from observations made in 1899-1900, before any improvements were attempted. At Mbamba there are two streams, each with a tortuous course (*see* map, p. 16), and at Ngani there are five (*see* map, p. 16 and plan). Four of these latter are quite short, and flow through hollows in the sand which have been planted with rice. One stream is 200 yards long, and part of its course is tortuous, and obstructed by reeds, which determine the formation of many pools. All the streams have ponds at the mouth, separated from the lake by a bar. A number of mosquitoes reared from larvæ collected from Mbamba and Ngani were identified by Dr. Daniels as *M. funesta* and *P. costalis.*

The nearest of these streams is about a quarter of a mile distant from the European station, and although the observations of Stephens and Christophers would indicate that this is within the range of flight of anophelines, the small number that reach the station show that the attempt is not usually made. It is only in May and June, when anophelines are specially plentiful, that they are at all commonly found so far from their breeding places. A gentle wind from the south, which not infrequently blows at night during these two months, seems almost to help them to cover the distance, for a distinct increase in the number of anophelines on the station has often been noticed after such a wind. One point deserves mention. In 1899, when these observations were begun, there was a line of four huts between Ngani and the European station, occupied by native retainers. They probably acted as resting places, and helped the anophelines to cover the distance. In 1904-5 they were removed, so as to procure more complete isolation from the village.

At first sight, the destruction of anopheline breeding places in an island like Likoma might appear easy, but in practice, the uncertain course of the streams through the sand and the rise and fall of the lake make it impracticable. Even if regular bricked drains were made, it would be quite likely that the rush of water, bringing down tons of sand from above, would block them up, and cut a new channel for itself. Moreover, the cost of such a scheme would be prohibitive, for lime cannot be procured nearer than 100 miles away, and costs £6 per ton, while cement from England costs nearly £17 per ton. Lastly, owing to the quantity of sand which the water brings down, coupled with the annual rise and fall of the lake, it is impossible to prevent the formation of a bar with a pond behind it at the mouth of each stream.

Some improvements have been attempted. The reeds which blocked the course of the streams have been cut away, and where the channel was tortuous it has been straightened. The rice field was bought up, and straight ditches cut through it. The ground was planted with bananas and pineapples and kept constantly weeded (*see* plan, p. 18). Owing to the sandy nature of their sides, these ditches constantly need attention, and in spite of every effort they continue to harbour larvæ. During the wet season an effort is made to keep a way clear for the entrance of the fish into the ponds behind the bars. After the rains, when the streams have ceased to run and these ponds are getting low but are not yet dried up, petroleum has been used successfully. While the streams are still running it would be of little use; it can only be used in small quantities, owing to the cost of freight to Lake Nyasa, which makes it very expensive. These measures have to some extent reduced the number of anopheline breeding grounds; but no complete destruction is practicable, and the lake shore will remain a permanent source of anophelines. Owing to the presence of native huts, with many children, in the immediate vicinity, there is every facility for such anophelines to become infected with sporozoits.

It is clear that the key to the problem of malarial prophylaxis at the European station lies in its comparative freedom from anophelines, owing to the distance which separates it from the nearest breeding ground. Had the original site been a quarter of a mile further inland, it is probable that absolute freedom would have been attained. No native hut must be allowed in the intervening space to aid the mosquitoes in their flight. For the rest, reliance must be placed on the most careful use of mosquito nets to avoid being bitten by occasional infected anopheline visitors, and a systematic avoidance of all excursions to the lake shore at night must be practised as far as possible.

The gradual adoption of these precautions has brought with it a marked improvement in the European health record. From 1899-1905 there have been no deaths, and only one person has been invalided. Some members of the staff have been quite free from malaria for a year or more, and several others have not had more than one or two slight attacks in twelve months. Some few people have had a series of obstinate relapses in spite of treatment, but no really serious cases have occurred.

A comparison of the following summary with that of the years 1885-98, gives very striking evidence of the improvement in health that has been obtained.

SUMMARY, 1889-1905 (*cf.* p. 17).

Total number of workers ..	27	(Of these, five were to some extent acclimatised, but the rest were quite new to the country.)
Total number invalided ..	1	
Deaths..	0	

Statistics of Blackwater Fever.—One patient had an attack; he recovered, and was invalided.

The average length of residence at Likoma for each worker was two years. Hence the invaliding rate was 18·5 per thousand, *i.e.*, less than one-tenth of what it was in the earlier period.

KOTA KOTA.

Physical Characteristics.

Kota Kota is the name of a large straggling native village built on the shores of a shallow lagoon, on the east side of Lake Nyasa. The inhabitants number about 5,000. Everywhere the shore is low and swampy, and is thickly-fringed with reeds, which grow out some distance into the water. Above this is a level sandy belt about half a mile wide, containing many low-lying patches which are flooded during the wet season, and are planted with rice. Between these rice fields are many native huts. Inland, the ground rises sharply to a height of about 100 ft. and then slopes gradually upward for nearly a mile. Native huts are built on this rising ground, and here, too, just on the edge of the village, are the European settlements, viz., two trading stores, the Government and Mission Stations.

The soil of this ridge and of the sloping hill behind is clay or gravel, with boulders of granite projecting here and there. The Mission property is a piece of ground about 20 acres in extent, which is closely surrounded by native huts. On either side are streams, one of which flows through very marshy ground (*see* plan, p. 26). The soil holds water very readily, and in the wet season all hollows are swampy, and the sub-soil water is everywhere within a few feet of the surface, and any pit remains full of water.

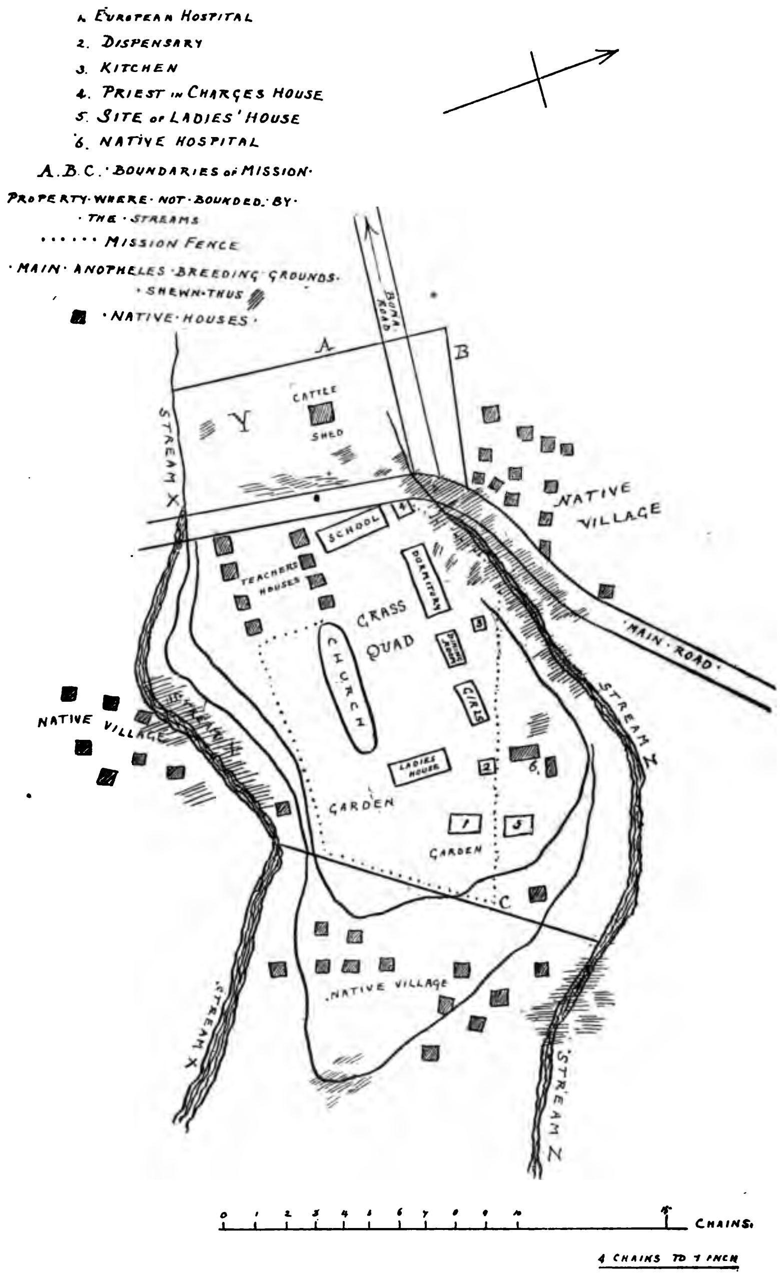
The rainfall at Kota Kota is heavier than at Likoma, being about 50 in. per annum, but the wet season has the same duration, viz., November to April.

A number of streams run through the village and rice fields. About July or August these dry up, but water is still obtained by digging near their beds. The natives obtain their water from these streams and water-holes, not from the lake, as the water of the lagoon is dirty. For Europeans, drinking water is brought from a hot spring two miles distant, the temperature of which is about 70° C., so that it is naturally sterilised, and does not require to be boiled.

On either side of the village there are miles of low-lying peaty soil where rice is cultivated. The climate is similar to that of Likoma, but rather cooler, and violent winds are not infrequent during the great part of the year.

History of the European Occupation.

Until 1892 Kota Kota was closed to Europeans; it was the great port for the slave trade across Lake Nyasa. After the declaration of the British Protec-



Plan of Kota Kota Mission Station.

torate the slave trade was stopped by a treaty with the chief, and a British Government official was sent there in 1894. In the same year mission work was begun, and in 1895 the present site of the mission station was bought.

During the next three years the European residents comprised the Government official, two missionaries, and two traders. In 1899 the mission staff was increased by the arrival of two ladies, one of them being a trained nurse. From that time onwards the staff has numbered between four and six, and there have been good permanent buildings. Fresh vegetables, milk, &c., are more easily obtainable there than at Likoma, and the standard of living has been better.

Mosquito Observations.

Kota Kota has the reputation of being one of the worst places on the lake for mosquitoes, and in view of the physical characteristics described above, this is not surprising. They appear in numbers in December as soon as ever the rainy season is established, and continue to be very prevalent until May. In June and July they diminish somewhat, owing to the drying up of breeding places. In a dry year (*i.e.*, if the rainfall has been below the average) they become scarce in August, but in a wet year they continue till September. In October and November they diminish very considerably, and are scarcely noticed, though in reality a number remain, ready to lay eggs as soon as the rains begin.

A great majority of these mosquitoes are not anopheles. Specimens of *Stegomyia* are plentiful, and are especially noticed during the day. After sunset and during the evening culicines are a constant annoyance. Breeding places abound everywhere. There is the usual collection of pots, tins and rubbish throughout the native village, and the swamps, water-holes, and rice fields supply additional breeding places.

The experiment of cleaning the mission compound of all tins, &c., has been tried; but although this may have caused a slight diminution in numbers, it was not very noticeable owing to the immigration of other mosquitoes from the surrounding neighbourhood. It is difficult to see what could be done to prevent this nuisance; a "mosquito brigade" is hardly likely to be organised by Government for the benefit of the ten European residents, and even if this were done, and all tins and rubbish cleared away throughout the native quarters, the swamps and ponds would still remain.

As regards anophelines, these are much less noticeable, but their presence in considerable numbers is revealed by the number of larvæ that can be found. As at Likoma, they tend to enter the houses at night, and are most easily observed in the mornings. During the wet season breeding places are everywhere present. They can be found among the reeds on the lake shore (*vide* Daniels' Report to the Malaria Committee), in the rice fields, by the sides of streams, in springs, in oozing water-logged ground, and to some extent in the native water-holes.

Towards the end of the dry season the streams and swamps and rice fields dry up, and some of the water-holes become too stagnant, but the edge of the lake remains as a permanent breeding place. This, however, is over half a mile from the mission station, and probably no anophelines reach it from this source; but they remain in the huts near the shore, and are a constant source of danger to persons going to or from the steamers at night.

It is obvious that no radical measures can be taken by the Government to destroy anopheline breeding grounds. The swamps are too extensive to be drained, and rice-growing is the most important industry in Kota Kota.

The main anopheline breeding grounds which were found to exist on the mission property are shown in the accompanying plan. They consisted of holes from which clay had been dug for building purposes, which in the wet season become ponds, on some unoccupied land (marked Y in the map), and the two streams which formed the boundaries on either side, of which one (marked Z in the map) flowed through a regular swamp, which was covered with rank vegetation.

On the principle that any reduction in the number of anophelines is an advantage, these holes and disused ditches have been filled up; a good ditch has been cut along the swampy ground, and the land cleared and used as a garden. This has reduced the number of breeding places, but, as was seen at Likoma, nothing short of a concrete drain, regularly flushed out, would prevent the ditch itself from sheltering some larvæ.

Such small local efforts at mosquito destruction are altogether of secondary importance, and the fact must be accepted that at a place like Kota Kota anophelines, many of them infected, will always be present.

It is obvious that prophylactic measures must be designed to protect Europeans from the bites of anophelines, and in the case of the mission station these have been systematically employed.

Mosquito nets have been constantly and intelligently used since 1899. In a sense the very number of mosquitoes and the annoyance they cause is an advantage, for it ensures care being taken about the condition of the nets.

A large percentage of these mosquitoes are culicines, and therefore harmless from the malarial standpoint, but in trying to avoid them, the more insidious anophelines are kept off at the same time.

In 1902 all the European houses were protected by means of wire-gauze screens in the doors and windows, each door being made self-closing by means of a spring. In practice this mechanical protection has been found to answer admirably, but it fails in proportion to the number of people who require to pass in and out after sunset, and unfortunately, in some cases, this number may be considerable, as a good deal of work has to be done after 6 p.m. Hence the mosquito net is still used as an additional protection.

With the dining room the mechanical protection also fails to some extent on account of the large amount of going in and out, and here the burning of a little pyrethrum powder under the table before dinner has been found to keep off the attacks of mosquitoes, as it stupefies them for an hour or so. Protection of the ankles by means of two pairs of socks, gaiters, or mosquito boots is also practised.

It may be noted in passing that the colour of the clothing seems to make no difference to the attacks of mosquitoes. Some experiments made by Nuttall and Shipley seemed to show that they preferred dark clothing, particularly Navy blue, and avoided yellow. This is doubtless true when they are choosing a resting place during the day, but experience shows that yellow socks or khaki clothes do not offer the least protection against their bites during the evening.

In the case of a missionary community, advantage cannot always be taken of mechanical protection; it is frequently necessary for the workers to go out of their houses or even to visit the native village after sunset.

Under these circumstances it has been thought advisable to adopt a regular quinine prophylaxis as an additional precaution, and quinine, gr. x., is taken on two consecutive days every week by each European on the station.

The value of these measures can be judged by the health record. On *à priori* grounds Kota Kota would be pronounced a most unhealthy station, owing to the prevalence of anophelines and the close proximity of native and European dwellings. Of course, the sites of the latter were chosen before there was any knowledge of the mosquito malaria theory, and were determined by consideration of practical politics rather than of health.

During the first pioneer period, 1894-8, out of six workers two died of blackwater fever and one was invalided.

The period from 1899-1905 may best be divided into two parts. During the first part, 1899-1901, when little was done towards prophylaxis beyond the systematic use of the mosquito net, out of eleven workers none had blackwater fever, but one died. This death occurred from hyperpyrexia within a month of the patient's arrival at the Lake.

During the second part of the period, 1902-5, when all the precautions enumerated above were employed, there were twelve workers; none were invalided and none had blackwater fever. One worker had only one attack of malaria in four years, another was two and a half, and two others were each one year without any attack. Three others, all of whom had a good deal of outside work in the evenings, suffered from malaria, which showed a specially obstinate tendency to relapse.

It is to be noted that during all this period, 1899-1905, there has been no case of blackwater fever among the members of the Mission. Among the traders and Government officials who took no special prophylactic measures, two people have been invalided away from the station, and there have been three cases of blackwater fever, one of which was fatal.

The following is a summary of the health record of the members of the Mission:—

SUMMARY, 1894-1898.

Total number of workers ..	6	(All except one new to the country.)
Total number invalided ..	1	
Total number of deaths ..	2	
Blackwater Fever	2	(Both fatal.)

SUMMARY, 1899-1905.

Total number of workers ..	22	All except one new to the country.)
Total deaths	1	
Invalided	0	
Blackwater Fever	0	

MALINDI.

Physical Characteristics.

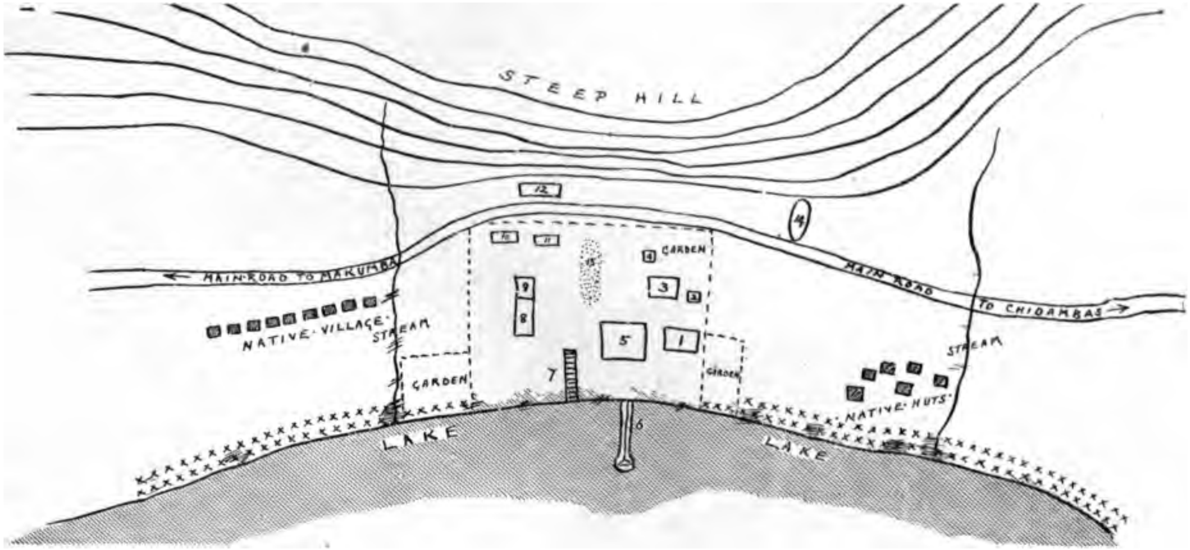
This is a typical lakeside station. It is situated at the extreme south-east corner of Lake Nyasa, at a spot where the wooded hills come very close to the water, leaving a narrow level belt of land, not over 150 yards wide, on which the station is built. Behind it the hills rise steeply to a height of 1,500 ft. above the lake. On either side of this spot to the north and south the hills recede from the shore, leaving a level expanse of fertile land from a ½ to 2 miles wide. Here are native villages and gardens; one large village is a mile to the south, and another 2½ miles to the north; there are also a few small hamlets nearer at hand.

In front of the station when the lake level is high is a steep clean sandy beach, on either side it is fringed with reeds, but these do not grow far out into the water as at Kota Kota, the waves from the lake wash in amongst them, and the shore is swept by winds.

There is a watercourse on each side of the station (*see* plan, p. 32). Throughout the rainy season these are mountain torrents, running only during and after the storms; but for a month or two after the rain is over there are permanent pools along their rocky beds. For seven months of the year they are quite dry.

Owing to the sandy, porous nature of the soil on which the station is built there is no swampy land anywhere in the neighbourhood. The climate is slightly cooler than at either of the stations already described. This is owing partly to its situation farther south, and partly to cool winds blowing from the lake or from the hills.

The rainy season begins rather earlier, *i.e.*, at the beginning of November, and lasts till March or April, and the rainfall is 35 in. per annum, as on the River Shiré.



PLAN OF MALINDI STATION.

(1) Ladies' house; (2) dispensary; (3) dining room and store room; (4) kitchen; (5) engineering shop; (6) pier; (7) slipway of C.J.; (8) European sickroom; (9) priest-in-charge's room; (10) boys' dormitory; (11) native hospital; (12) school; (13) probable site of new church; (14) present church; × × reeds on lake shore; --- Mission fence; / // anopheles' breeding ground.

History of European Occupation.

The station was started in 1898, and it has served as the engineering headquarters in connection with the construction and repairs of the steamers.

The usual staff has been two ladies (one a trained nurse), one clergyman, and one to four engineers, according to requirements. A stone house was built at the very beginning, and there was no pioneer period such as occurred elsewhere.

About a hundred yards north of the European station is a row of native huts, where the native artisans were housed while the steamer was under construction. Of late years they have been used for teachers and servants. Apart from the Mission there is no other European settlement at Malindi.

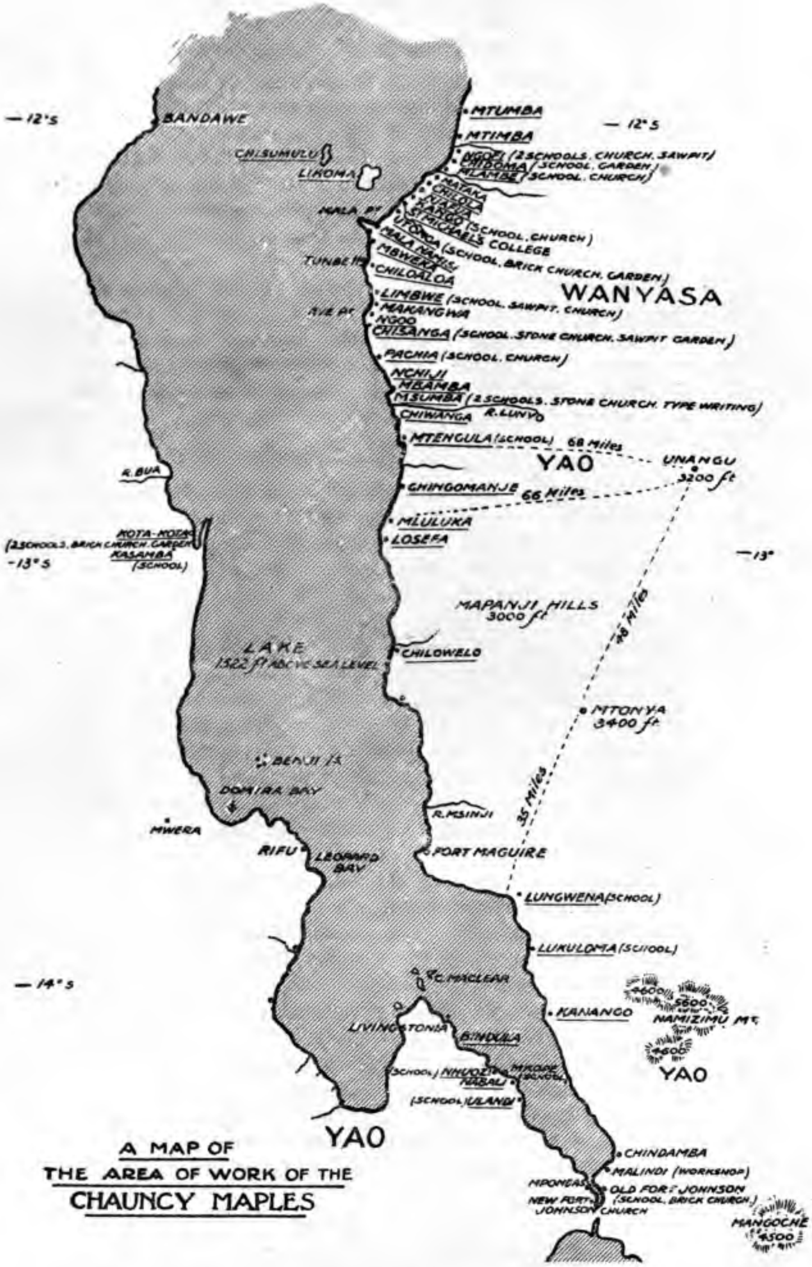
Mosquito Observations.

For a year or two after the station was opened the level of the lake was high, and the shore shelved steeply. It afforded few possible breeding places for anophelines. There may have been a few chance pools in the sand, but these were scarcely permanent enough, and the larvæ would probably have been washed out into the lake. The reeds on either side of the station were not thick enough to keep out fish.

The two streams which bound the station are flushed out after every rain, as the water comes down with great force from the steep hills above. Moreover, the beds are rocky, so that very little sand is brought down, and no bar forms at the mouth. It is true that after the rains are over in April and May there are some rock pools in their courses which form suitable breeding places for anophelines, but these dry up in two, or at most three, months.

Under the circumstances, as might be expected, the station was almost free from mosquitoes. Anophelines were seldom seen. If culicines were present, it meant that they were bred on the spot, and all that was necessary was to organise a brigade to clear up rubbish.

During the last three years, however, a considerable alteration has taken place. The level of Lake Nyasa has fallen by over 3 ft. Whether this is temporary, or whether it is a permanent result of the deforestation of the country which is in progress, has not been determined.



A MAP OF
THE AREA OF WORK OF THE
CHAUNCY MAPLES

At Malindi the effect has been to quite alter the character of the beach. Below the shelving part is a nearly flat, uneven expanse of sand, and now as the lake level falls each dry season, this is exposed. Here pools suitable for both anophelines and culicines to breed in are of frequent occurrence. They are often stretches of water several yards long, where there is a hollow in the sand, shut off from the lake by an intervening ridge. At other times they are pools formed by back eddies, or by the rush of water down the beach during a rainstorm.

The reeds have increased in thickness, and drift material mixed with sand is apt to collect among them, and shut off little pools at the edge of the lake, so that fish cannot reach them. All these breeding places are somewhat uncertain, and the waves raised by a storm in the lake may wash most of them away; but they form again in a few days, and larvæ, both of anophelines and culicines, can readily be found in them. The season when the condition of the lake shore is at its worst is between June and August; in April, when the lake is at its highest, it still reaches up to the steep beach, and by September it has fallen below the flat part, and the slope of the shore is again steeper, so that few pools form.

Little can be done in the way of mosquito destruction. Cutting the reeds is a help, and sometimes if pools are few, they can be filled up; but the greatest difficulty lies in their varying position. In August, after the lake has fallen sufficiently, any remaining hollows can be filled in, and the wet ground planted with vegetables. This has been satisfactorily tried on both sides of the station.

It must be recognised, therefore, that so long as the lake level remains low, there will be a considerable number of anophelines breeding on the shore, especially between May and August, and as the European houses are only 50 yards distant, they are within easy reach. On the other hand, fortunately for the health record of Malindi, there is practically segregation of the Europeans. The main native villages are over a mile away on either side, and the steep hill prevents any building behind the station.

The key to prophylaxis is the maintenance and improvement of this isolation. With this object in view more land has been rented on either side of the station, so as to prevent the building of native huts, and on the first opportunity a few dwellings, which are only about 150 yards away, will have to be removed. In the village occupied by the native servants there must be no more huts than are absolutely necessary, and, as far as possible, only adults must be allowed to inhabit them. Any new huts must be built on the site remote from the station.

As a matter of course, mosquito nets are in use, and in addition to this the European hospital has been protected with wire gauze. If the lake does not rise again it may be necessary to employ mechanical protection throughout the station, as has been done at Kota Kota, but it is doubtful whether mosquitoes are troublesome enough to make people careful in the use of such protection, and without the willing co-operation of the inmates mechanical protection of houses is of little use. For the present, reliance has been placed on segregation.

As mentioned above, there was no pioneer period at Malindi, and the health record must be compared with the later periods at other stations. It has been on the whole very good, and in spite of the increase in mosquitoes, there has been no marked falling off in the last few years. There has been one death, but this was almost certainly due to general peritonitis following on appendicitis, and therefore in no way the result of malaria. Three members have been invalided. One was young and neurotic, and was sent home as an unsuitable subject for Africa. The other two suffered from blackwater fever, but one of them was a person who refused to conform to any rules of hygiene. On the other hand, one member has been in residence three and a half years with no attack of malaria, and others have had over a year with no attack. No one has had really bad health.

SUMMARY, 1898-1905.

Total number of workers ..	24	
Total number invalided ..	3	
Deaths..	1	(Not due to the climate.)

THE STEAMERS.

Conditions of Life and Work on Board.

There are altogether seven steamers plying on Lake Nyasa, and it falls to the lot of most of the settlers in the neighbourhood to travel by them from time to time, so that the healthiness or otherwise of steamer life is no negligible factor. The Mission steamer, the *Charles Janson*, was built in 1885, the same year that the settlement took place at Likoma. In 1902 this was superseded by a larger boat, the *Chauncy Maples*. In addition to carrying stores and passengers to all the European stations, the steamer has a staff of clergy, who supervise schools in a large number of villages, mainly situated along the eastern shore of the lake.

In considering the conditions of health, it is necessary to distinguish between life aboard and life ashore. The villages, like all others in Central Africa, are centres of malarial infection. They are generally built close to the lake, at the mouths of rivers or streams, where fish can be caught, and often there are rice fields immediately behind, so that the conditions are eminently favourable for the development of anophelines. In the day-time this is of no consequence, but sometimes it is necessary for the clergy to sleep ashore, or to spend a few days on land travelling from village to village. This undoubtedly exposes them to considerable danger of infection, but it cannot be avoided, and the only precautions possible are the rigid use of the mosquito net and the prophylactic use of quinine.

The captain, the engineer, and the passengers always sleep aboard, and it is from their record that a true estimate of the healthiness of steamer life may be obtained.

Mosquito Observations.

It is very noticeable that the steamer remains practically free from mosquitoes. Balfour[1] has recorded the fact that *Stegomyia* and *Culex* breed freely in the bilge water of the steamers on the Nile, but in the case of a lake steamer, which has to be kept in a thoroughly seaworthy condition, this never happens, for it is regularly washed down and the bilges are pumped dry. Even when mosquitoes are very prevalent ashore they do not seem to cross the 200 or 300 yards of water, and they certainly are not attracted by the steamer lights, though the *Ephemeridæ* may swarm round them in thousands. Those mosquitoes that do succeed in reaching the steamer come with the boats. They have been observed at Likoma, Kota Kota, and Malindi; at these places, owing to the presence of European stations, there is more communication with the shore after dark, whereas, when the steamer is anchored off a native village the boats are often hauled up before sunset. Those mosquitoes which reach the steamer seem soon to get blown away, and they very seldom find their way below into the cabins.

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[1] First "Report of the Wellcome Research Laboratory," Khartoum, 1904.

Mosquito nets are not in use on board. It would doubtless be a counsel of perfection to use them, and they are supplied, but in practice, with narrow berths and hot, stuffy cabins, it has not been found possible to insist on their use, especially as there is an almost total absence of mosquitoes. In spite of this, the health of the European officers and passengers has been very good, and the experience gained with other steamers on the lake has been the same. It is almost impossible to quote definite statistics, for the officers sometimes go ashore for awhile between the trips of the steamers, and if they come aboard at night there is always the possibility of infection on the lake shore. It has frequently been shown that a month's trip on the steamer is an excellent means of bracing up a convalescent from a land station.

The most noticeable fact in connection with the steamer is the almost complete protection afforded by a comparatively narrow strip of water. Distance over water seems more effective than the same distance on land. Possibly the mosquito instinctively flies inland, where experience has taught it to look for food, and it avoids endeavouring to cross the generally void expanse of water.

Other Stations.

The Universities' Mission has two other stations, viz., St. Michael's College, on the east shore of Lake Nyasa, opposite Likoma, and Mpondas, on the Upper Shiré River, near Fort Johnston. It will not be necessary to describe these in detail. Both of them are small stations, the usual staff only consisting of two Europeans, so that the number of workers is too small to supply any reliable statistics. Moreover, it has not been possible to carry out such definite prophylactic measures, but when attempted they have been similar to those already described.

Thus St. Michael's College resembles Malindi, in that it is a lakeside station, comparatively isolated, but with many anopheline breeding grounds on the shore. Prophylaxis must be directed mainly towards segregation.

At Mpondas the grass-grown sides of the River Shiré are a constant source of anophelines, and the station is surrounded by native huts. The conditions are very similar to those at Kota Kota, though even more unfavourable, since a relatively large percentage of the total mosquitoes are anophelines.

Mechanical protection of houses, and routine quinine administration, are the prophylactic measures to be recommended, and these have been recently attempted. At the township of Fort Johnston, a few miles distant, where there are between twenty and thirty European residents, extensive operations have been undertaken to clear the banks of grass, and the native population has been moved away; but these measures can only be carried out by the Government, and are not applicable to an isolated station.

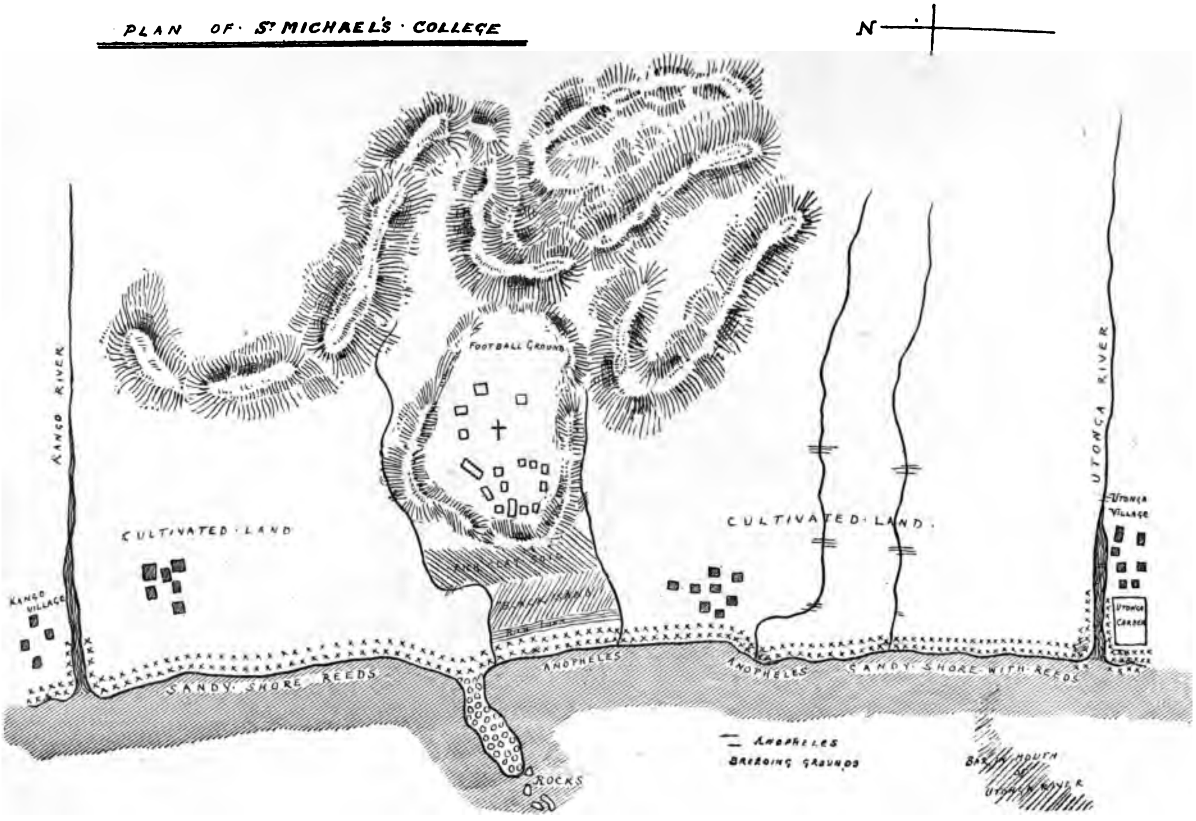
Results.—General Review of Health Record.

Typical stations have now been described, the special conditions of each have been considered, and the methods of malarial prophylaxis which have been found most suitable have been detailed. It remains to give a general summary of the health statistics of the whole body of missionaries, and so to test the efficacy of the methods that have been employed.

The table shown on p. 41 gives these statistics at a glance.

The three periods that have been noticed before are clearly shown here. First, an early period of moderate health, when there were a number of acclimatised workers; secondly, a period of rapid increase in numbers without the adoption of special precautions, resulting in a large number of cases of blackwater fever, many deaths and many invalidings; lastly, from 1899 onwards, in spite of a further increase in numbers, a period of steady improvement. This is due in part to a more careful selection of candidates, to a better style of living, and to the provision of satis-

PLAN OF ST MICHAEL'S COLLEGE



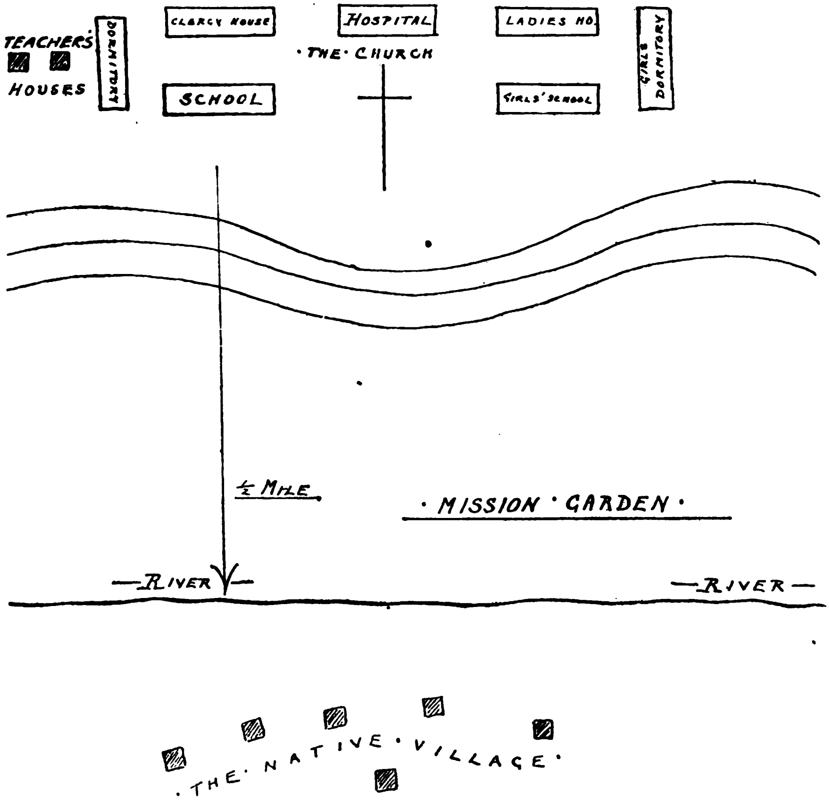
factory hospital accommodation and nursing attention, but largely to the adoption during the last few years of practical methods of malarial prophylaxis based on the mosquito malarial theory.

HEALTH RECORD, 1887-1905.

Year	No. of workers	DEATHS		INVALIDING		ATTACKS OF B.W.F.	
		No.	Per 1,000	No.	Per 1,000	No.	Per 1,000
1887	12	1	83	—	—	—	—
1888	14	1	71	—	—	—	—
1889	11	—	—	2	182	—	—
1890	12	—	—	—	—	—	—
1891	14	1	71	—	—	—	—
1892	16	2	125	2	125	1	62·5
1893	22	—	—	3	136	1	45
1894	22	2	90	3	136	2	90
1895	23	3	130	4	174	3	130
1896	19	—	—	—	—	2	105
1897	23	3	130	1	43	5	217
1898	23	2	87	1	43	2	87
1899	26	1	38	2	77	1	38
1900	31	1	32	4	129	3	97
1901	32	1	31	—	—	—	—
1902	35	1	29	—	—	—	—
1903	37	—	—	—	—	1	27
1904	39	—	—	2	51	2	51
1905	39	—	—	2	51	2	51

The steady diminution of the mortality is very striking. In the case of blackwater fever and invaliding statistics, it may be further noted that no less than six out of the total of nine cases of blackwater fever occurred at the two small stations of St. Michael's and Mpondas, where a definite scheme of prophylaxis was hindered or delayed, and only three are attributable to the large stations of Likoma, Kota Kota, and Malindi, where prophylactic measures were more systematically carried out. It is to be noted that the statistics of the last few years compare very favourably with those of the Protectorate as a whole, and this in spite of the fact that they are all obtained from stations situated on the lake level, whereas the majority of the Europeans occupy the healthier Shiré Highlands.

No less favourable is a comparison with the most



Plan of an Ideal Mission Station.

recent statistics from another Central African Protectorate, viz., Southern Nigeria, which are as follows :—[1]

		Death-rate.	Invaliding-rate.
1901	..	42 per thousand	118 per thousand
1902	..	27 ,,	118 ,,
1903	..	26 ,,	117 ,,
1904	..	38 ,,	84 ,,
1905	..	22 ,,	150 ,,

These results would seem to justify the conclusion that in spite of the disadvantages of working on a small scale in outlying districts, situated in a very malarious part of Tropical Africa, it is possible to select such methods of malarial prophylaxis as will cause a very marked improvement in the health of the European settlers. If this can be achieved in the case of missionaries, who from the nature of their work are not always able to avail themselves of the protection afforded, still better results should be obtained in the case of Government officials and traders, whose work is generally over by sunset, and who can spend their evenings where and how they will.

If in founding new stations the necessary precautions were kept in view from the beginning, the success should be far more striking.

General Conclusions.

It now remains to recapitulate the conclusions and to enunciate the principles which must determine the selection of methods of prophylaxis in other cases.

It may be premised that in outlying districts it is not possible, as it may be in towns, to select one plan to the exclusion of others, and place complete reliance on it, and to apply it to all cases. The physical conditions, climate and general surroundings of each settlement must be considered, and methods that appear most suitable must be adopted. In general it may be said that if possible it is always best to employ two distinct methods at the same time, for it is probable that neither can be carried out ideally, and one may supply the deficiencies of the other.

Mosquito destruction has been found to have a very limited application in the country. When applied to culicines it is a useful sanitary measure. A mosquito brigade to clear up the compound, remove rubbish, and hoe up all long grass and bush, should always be instituted; this, however, is not malarial prophylaxis. General destruction of anopheles' breeding grounds cannot be efficiently carried out; the work required is too extensive, and the cost in the interior of Africa is prohibitive. Small local areas of marsh or swampy streams may be dealt with by ordinary surface drainage, a proceeding which may be advantageously coupled with cultivation of the ground as a garden; for then the ditches are more likely to be kept in order. This may effect some reduction in anophelines, but not such as can be relied on to secure any definite beneficial results.

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[1] "Colonial Medical Reports," Journal of Tropical Medicine, October 1, 1906.

Without attempting anopheline destruction, however, it may be possible to attain the same result by selecting a site which is naturally free from these insects. Such sites can sometimes be found in Tropical Africa. The interior of Likoma Island is free from breeding places. The healthiness of the European station there is mainly due to its situation —a quarter of a mile back from the lake; had it been built half a mile back it would probably have been quite free from anophelines. Such sites possess enormous advantages from a health standpoint, and they are probably really commoner than is often supposed. A hill overlooking the lake or a river is most likely to supply the conditions.

Certain disadvantages must be reckoned upon. The soil will probably be sandy and barren, so that shady trees and a pretty garden near the house must be dispensed with: but a vegetable garden might be made near the water supply half a mile away, and the intervening ground could be cultivated during the rainy season. All water would have to be carried half a mile or so (unless rain-water were stored in tanks) but this only means a slight increase in water-carriers' wages. Lastly, as native villages are always built near water, and generally on fertile land, such a site is necessarily at some distance from the village, which, though eminently beneficial from a health standpoint, may in some cases be considered a disadvantage. In the case of a lakeside station, the native village will probably be on the shore in front; in an inland station it would be ideal on the opposite side of the river.

Appended is a rough plan of such a proposed station.

Mechanical Prophylaxis.—In the elementary form of the mosquito net this is always to be recommended.

In its more complete form—gauze-protected houses, aided, if need be, by protection of the ankles, and fumigation with pyrethrum—it is applicable to stations built of necessity on unhealthy sites, especially where anophelines are abundant, and native huts are in the immediate vicinity. Such mechanical prophylaxis requires the intelligent co-operation of every European member of the community; there must be careful compliance with regulations and a certain curtailment of liberty. Human apathy is such that unless obedience to rule is made easy by the dictates of comfort in consequence of the prevalence of mosquitoes there is danger lest precautions should be omitted, and carefully devised schemes rendered futile.

Planters and Government officials might be con tent to trust entirely to the protection afforded by mechanical prophylaxis, but in the case of missionaries, owing to the extra risk consequent on the large amount of evening work which is often required of them, it should be supplemented by the prophylactic administration of quinine.

Segregation of Europeans where it can be obtained is admirable in its simplicity and efficient in its results. Political or business considerations, however, may render it impossible, and where stations were established before any such ideas were mooted they often cannot be moved. Moreover, in the case of isolated settlements it may be difficult of attainment. The most suitable sites are often already occupied by native huts, and Government is very unwilling to grant private individuals any powers of compulsory eviction. Moreover, owing to dangers from wild beasts, &c., a lonely situation in Central Africa is not pleasant.

It must be remembered that native dwellings are nearly always placed close to water, and, therefore, if a site is found free from water and from anophelines (*see* pp. 43 and 44) it will also be devoid of native dwellings, and the double protection of freedom from anophelines and segregation from the natives will be obtained with little trouble.

Complete segregation cannot be carried out in the case of missionaries, as their work requires frequent contact with the natives. It is, however, generally possible for the mission station to be built some distance away from the village. Boys and girls under instruction will be required to sleep on the station, but married persons with children can be best located in the village. This means that natives sleeping on the station will be between the ages of 10 and 20, and the children under 10, who are the real infecting agents, will be in the village. Thus, even in the case of a mission, the most needful factor, viz., segregation from native children, will be obtained.

Koch's method of the general administration of quinine to the native population is obviously one which could only be undertaken by the Government, and which is, under any circumstances, unsuited to country districts. The free distribution of quinine to the personal servants and retainers of the Europeans is frequently practised, and is beneficial as far as it goes.

The Prophylactic Use of Quinine by Europeans.—This is the least certain method, and wherever possible it should not be employed alone, but as a subsidiary measure it is of great value. It may be generally stated that its use is advisable in proportion to the difficulty of efficiently carrying out the methods previously described.

It should always be adopted where the natural conditions of the station are particularly unfavourable, where there is exceptional exposure to infection (as by sleeping in native villages), or where the precautions that have been devised seem likely to break down, and attacks of malaria result. Further, it can always be advised as an additional precaution, even when it cannot be enforced as a rule.

Lastly, there is the need for *the education of public opinion.* Though it is now seven years since the truth of the mosquito malaria theory was absolutely demonstrated, it is by no means uncommon to find settlers who, in deed if not in word, express their disbelief in it, and declare that " Malaria is the natural result of the climate, and that the sooner people have it and get over it the better."

It is necessary firmly to maintain the opposite proposition, viz., that malaria is an infectious disease present everywhere in native villages; that by the employment of their knowledge and ingenuity Europeans can frequently avoid it; and that often the habitual sufferer from malaria has only himself to blame.

Whatever methods of prophylaxis are adopted on a station, the medical authority will have to explain the principles on which they are based, and then he must constantly insist on the importance of compliance with the necessary regulations.

Persistence is generally rewarded, and, as definite improvement in the health record becomes apparent, indifference and incredulity gives way.

The newcomer to Africa generally has an exaggerated fear of the danger of the climate, and is an apt pupil; and if sound anti-malarial habits are formed in him from the beginning, they become the natural accompaniment of his residence in Tropical Africa.

Summary showing improvement that has resulted from measures taken directly with the intention of reducing the amount of malaria.

Divided into periods it will be seen that the rate per annum of deaths, invaliding, and blackwater fever are indicated in the table.

	Average number of workers	Deaths per 1,000	Invalided per 1,000	Blackwater fever per 1,000
1887-1890	12·25	40·8	40·8	—
1891-1895	19·4	82·5	123	72
1896-1900	24·4	57·4	65	106·5
1901-1905	36·4	10·9	21·8	27·5

It was during the last period that prophylactic measures were undertaken, and the number of deaths of persons invalided and of cases of blackwater fever are all seen to be enormously reduced.

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